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TRANSLATION

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Title:	Locking-synchronizing System for Positive Locking Clutches, Notably in Automotive Change Gears
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SPECIFICATION

The invention concerns a locking-synchr nizing system for positive-locking clutches, notably in automotive change gears, with a positive-locking element arranged on the shaft and axially movable for meshing, and with a friction element capable of limited rotation and interacting with the gear to be engaged, and mounted indirectly on the shaft, and with locking elements, or abutments for such, capable of limited rotation relative to the positive-locking element upon occurrence of a friction moment, the synchronizing force from the friction moment of the component to be synchronized being borne by bevels provided on annular bodies joined to the shaft. A locking-synchronizing system of the aforementioned type is known as such. The friction element necessary for synchronization is rigidly connected to the bevels generating the servo force. Owing to this design, the friction element is in the synchronizing process abruptly forced on the gear to be engaged, with its friction surface, without any possible, specific maximum limitation of the contact force. The latter may rise to a very high value, requiring a very heavy design of the synchronizing system, allowing it to absorb this force. Furthermore, the synchronization occurs abruptly, greatly stressing the transmitting members arranged in the drive train.

The problem underlying the invention is to avoid the above disadvantages. Additionally, a simple structure and narrow design of a locking-synchronizing system is being sought.

These problems are inventionally solved in that the positive-locking element travels in the synchronizing process, r lative to th shaft or an annular body joined to it, a displacement path until the locking elements

come to bear on an axially parallel surface of the said shaft r the annular body joined to it, respectively. Due to this displacement path and the spring constant of a spring arranged between positive-locking and friction element, a maximally determined spring force is via compression bodies stored elastically, which as a contact force of the frictionally engaged elements acts on the gear being engaged, as a force being proportional or equal to said spring force. Upon rotation of the frictionally engaging element relative to the positive-locking element, the axial shift of the latter is locked out by mutual contact on noses, thereby preventing the positive-locking element from engagement with the gear to be engaged.

Once synchronization has been initiated, the contact force of the friction surfaces coordinated with the components to be engaged can maximally not exceed a very specific value. This makes it possible to favorably allow in the design of the locking-synchronizing system for its wear, size, service life and reliability. With the path of the frictional elements relative to the positive-locking elements, and thus also the spring deflection being limited in the synchronization, also the force stored in the springs is maximally limited. This force equals or is proportional to the contact force of the friction surfaces.

In one embodiment of the invention, the locking members fashioned as meshing toothing are arranged on the positive-locking element and interact for generation of the contact pressure with the locking elements arranged on the annular body, which are fashioned as pilot teeth. Provided as locking elements, in the frictionally engaging component, are compression bodies fashioned as ball pins and interacting as abutments with the noses in the positive-locking component. Additional locking members which are ef-

fective without the occurrence f a friction moment are provided, for locking at abrupt actuation, between the positive-locking element and the annular body arranged on the shaft. Thus, a positive locking of the components to be engaged cannot occur without preceding frictional engagement up to synchronism of the parts to be engaged. The force generated within the locking-synchronizing system, from the frictional moment of the parts to be synchronized, is intended to be available still, in part, for the positive-locking engagement.

In another embodiment, the locking elements are fashioned as balls and fitted in the positive-locking component. These balls slide in the synchronization process on radial bevels. The compression bodies arranged between frictionally engaging part and positively engaging part are fashioned as blocks which on the frictionally engaging element itself are arranged in rotationally fixed, but axially movable fashion. Instead of individual blocks, also a ring could be used as compression body.

Lastly, it is inventionally also conceivable to connect the positive-locking element, for actuation, with a shift rod 53 fitted in the shaft and to make said shift rod axially displaceable by means of a selector fork which is effective beside the gear array and, as the case may be, outside the gearbox casing. Especially favorable is fashioning the frictionally engaging element 80 as a continuous ring with roof-shaped outer friction surfaces and providing in it several holes, for instance three, for accommodation of the compression bodies and the springs coordinated with them. This design results in a simple structure and narrow design with a large diameter of the friction surfaces.

All of the illustrated embodiments of the invention feature the design as change clutch that is customary, f r instanc in autom tive change gears. In these, the frictionally engaging element is designed as a single-part twin male taper. Naturally, the inventional locking-synchronizing system can be used also in a single-acting shift clutch.

Embodiments of the locking-synchronizing system according to the invention are illustrated in the drawing, which shows in

Fig. 1, a locking-synchronizing system in longitudinal section;

Fig. 2, the system according to Fig. 1 in cross section;

Fig. 3, a section along line III-III in Fig. 1, as a development in a plane;

Fig. 4, a detail according to point A relative to Fig. 2, scaled up;

Fig. 5, the detail relative to Fig. 4 in plan view;

Fig. 6, a further embodiment according to the illustration Fig. 3;

Fig. 7, another embodiment of the locking-synchronizing system, in longitudinal section;

Fig. 8, the embodiment according to Fig. 7 in cross section;

Fig. 9, a detail according to point B relative to Fig. 8, in locked position;

Fig. 10, the locking-synchronizing system in a further embodiment, in longitudinal section.

In the embodiment according to Fig. 1 and 2, the force transmission from gear 7, or 8, to the shaft 9 and vice versa occurs by positive locking. An annular body 10 is fastened on shaft 9, for instance by a spline, in axial and rotationally fixed fashion. The annular body 10 possesses on its periphery two rim gears 11, as can be seen readily fr m Fig. 3. Said

rim gears 11 are on their circumferenc interrupted several times, for instance three times, by groups of pil t blocks 12, f which two each oppose each other in peripheral direction.

As can be seen from Fig. 1 through 3, a positive-locking element 13 fits axially on the annular body 10 and is movable in peripheral direction. It consists of two concentrically nested rings 60 and 61 joined to one another by several stays 62, for instance three, provided on the circumference. The inner ring 60 of the positive-locking element 13 possesses on its inside locking members 14 fashioned as engagement teeth and locking members 14' serving as pilot teeth. The locking members 14 have the same pitch as the rim gears 11; the number of locking elements 14' matches the number of groups of pilot blocks 12. The locking elements 14' engage between the pilot blocks ~~14~~ 12?, generating an axial thrust in a fashion yet to be described.

From Fig. 3 it follows that the locking elements 14' feature bevels 64 on axially opposed sides. The pilot blocks 12 oppose one another in pairs, causing the locking element 14' to travel from its center position, in clutching, to the relevant clutch side, a stairstep path. The pilot blocks 12 possess bevels 65 having the same inclination as bevels 64 of locking element 14'. The pilot blocks 12 are provided with stop surfaces 67 that limit the rotation between the positive-locking element 13 and the annular body 10 on their simultaneous axial path, thus determining the maximum contact force of the conic friction surfaces 72 and 73 upon the gears 8 or 7 to be meshed. In disengaged state, hence in the center position of the locking-synchronizing system, the l cking element 14' bears with its axially parallel surfaces 68 on the as well axially parallel

surfaces 69 of the pil t blocks 12, in a fashion such that in its peripheral rotation it will bear n said surfaces, thus cann t slid n the bevels 65. This is important in order not to trigger a meshing process as the positive-locking element 13 is retarded, for instance with a selector fork 23 yet to be illustrated.

From Fig. 1 and 2 it can be seen that the positive-locking element 13 is held in its center position relative to the annular body 10 by several spring-loaded ball pins 15, for instance three. In this center position, the locking members 14 and rim gears 11 as well as locking elements 14' and stops 66 are axially opposed (refer to Fig. 3). This axially opposed arrangement guarantees upon abrupt actuation of the selector fork 23 a locking without transmitting any friction moment.

The positive-locking element 13 possesses several slide tracks 70, for instance three, distributed across the circumference (Fig. 1 and 4) and arranged above a locking member 14 or locking element 14'. Fig. 4 shows a scaled-up section through such a slide track. Said track is formed by a conic catch 16 in the inner ring 60 and extends in axial direction, toward both sides, into the trough-shaped grooves 18 bordering on the outside, through an aperture 17 that has only the width of the compression body 19. The transition 79 of the trough-shaped grooves 18 to the aperture 17 is tapered.

From Fig. 1 and 2 it follows that in the frictionally engaging element 22 a compression body 19 is fitted that is designed as a ball pin which, in the illustrated embodiment loaded by a spring 20 in its center positi n, is forced int the conic catch 16. Said compression body 19 represents the elastic connection between positive-locking element 13 and

frictionally locking elem nt 22. Spring 20 is f ll wed by another, stronger spring 21. Said spring 21 is effective only after a specific travel of the compression body 19, or only in synchronization. The weaker spring 20 bears on the spring 21, which is arranged in a hole of the ring-shaped frictionally engaging element 22 with prestress.

The frictionally engaging element 22 is situated concentrically between the inner and outer ring of the positive-locking element 13 and possesses on its periphery as many openings 71 as the positive-locking element 13 possesses stays 62 (refer to Fig. 2). The stays 62 of the positive-locking element 13 protrude with play through the openings 71 in the frictionally engaging element 22, as a result of which the positive-locking element 13 is relative to it rotatable and axially movable.

The single-part frictionally engaging element 22, viewed axially from the central position of the compression body 19, possesses two outward-pointing conic friction surfaces 72 which in the synchronizing process bear on the conic friction surface 73 of gear 7 or 8, respectively. Outer ring 61 of the positive-locking element 13 is engaged by a selector fork 23 that initiates the meshing operation.

The mode of operation of the locking-synchronizing system is as follows: As the selector fork 23 shifts axially and, thus, moves the positive-locking element 13 to the left, e.g., the frictionally engaging element 22 is entrained by the spring-loaded compression body 19 until the friction surface 72 bears on the friction surface 73 of the gear 7 to be engaged. Owing to the difference in speed of rotation between power input and power output, a friction moment occurs as the friction surfaces 72 and 73 make c ntact. Said friction moment attempts a conc mitant r tation f

the positive-locking element 13 via compressi n body 19. Said moment bears via the bevels 64 of the l cking elements 14′ (refer t Fig. 3) on the bevels 65 of the pilot blocks 12 of the annular body 10, thereby producing an axial force that amplifies the frictional engagement on the friction surfaces 72 and 73. Bevels 64 of locking elements 14′ slide on bevels 65 of the pilot blocks 12 until striking the stop surfaces 67. In this process, the contact force of the friction surfaces 72 and 73 would increase in uncontrolled fashion, if a rigid connection existed between the frictionally locking element 22 and the positive-locking element 13. In this motion, the positive-locking element 13 has been pulled through beneath the compression body 19 in the direction of engagement, that is, presently to the left. The compression body 19 climbs up on the conic shell of catch 16 in a direction resulting from the axial motion and rotation of the positive-locking element 13 relative to the compression body 19 (refer to Fig. 5). The compression body 19 continues to climb up along the conic shell while counteracting the effect of spring 20 and spring 21, until the surfaces 68 of locking element 14′ make contact with the stop surfaces 67 of the pilot blocks 12 on the annular body 10 (refer to Fig. 3). The maximum contact force occurs in this position. Its magnitude matches the force stored in the spring 21.

In its limit position relative to the catch 16, the compression body 19 has assumed position 25 (refer to Fig. 5). A nose 74 prevents it in this position from entering the aperture 17. A further axial motion of the positive-locking element 13 is not possible (lock-out position in Fig. 4 and 5). The force required for lifting the compression b dy 19 to its position 25 is proportional to the contact force f the friction surfaces

72 and 73 and can be set and limited accurately by selecti n f spring 21. Said contact force is n t intr duced by the shift link via select r f rce 23, but is generated by bevels 64 of the locking elements 14' from the moment of friction.

Initiated manually via selector fork 23, a continued axial shift of the positive-locking element 13 is possible not until the moment of friction on the friction surfaces 72 and 73 has been eliminated, that is, with synchronism established between shaft 9 and gear 7. Only now is the frictionally locking element 22 able to rotationally recoil under the force of spring 21, relative to the positive-locking element 13. Hence, the compression body 19 slides back along the same track of the conic shell of catch 16 until relaxation of spring 21, that is, up to position 28. In this sliding retraction, the surface 68 of element 14' has been removed somewhat from the stop surface 67 of pilot block 12.

By exertion of limited manual force on the selector force 23 it is now under further retraction of the frictionally engaging element 22 relative to the positive-locking element 13 possible for the compression body 19 to enter the connecting aperture 17 (refer to Fig. 5). The compression body 19 has assumed position 26 in the connecting aperture 17, while the locking members 14 and locking elements 14' of the positive-locking element 13 have slipped into tooth spaces 78, along bevels 77 on the rim gear 11 and, respectively, along the edges of pilot blocks 12. The difference in height *h* (Fig. 4) b n the bottommost position of the compression body 19, in center pos , and position 26 of compression body 19 in the connecting aperture, respectively its bottom, corresponds just to the compression of spring 20, so that overcoming *h* always requires only the

application of a slight manual f rce n the s lector f rk 23 (refer to Fig. 1 and 4).

Following a short sliding through the connecting aperture 17, the compression body 19 arrives on the conic transition 79 of the trough-shaped groove 18. Owing to the residual moment of the moving masses, the frictionally engaging element 22 is rotated somewhat relative to the positive-locking element 13, and the compression body 19 climbs up along the conic transition 79 of the trough-shaped groove 18. The positive-locking element 13 is thereby forced, beneath the compression body 19, in the direction of engagement. Hence, it slides beneath the compression body 19 inside the tooth spaces 78 until striking the straight sides of the locking members 14 and locking elements 14' on the straight sides of teeth 75, which are provided as external toothing on the gear 7, or 8, directly beside the rim gears 11. As said teeth make contact, the force seeking to shift the compression body 19 through the conic transition 79 rotationally relative to the positive-locking element 13, acts back on the frictionally engaging element 22 in such a way that it lifts off the friction surface 73 of the ring gear 7, with its friction surface 72. Compression body 19 is now in position 27 (Fig. 5). Following this lift-off, relaxation of spring 20 allows the compression body 19 to proceed to the center of the trough-shaped groove 18. The positive-locking element 13 with locking members 14 and locking elements 14' begins to rotate relative to the gear 7 with teeth 75 and, as soon as locking members 14 and locking elements 14' are staggered, all [illegible] shed with teeth 75 of gear 7, without requiring any pointing of the locking members and locking elements. The locking-synchronizing process is completed. The components t be engaged

are in mesh. When the locking members 14 and teeth 75 happen t be staggered from the outset, engagement occurs immediately. In the synchronization according to Fig. 6, the locking members 29 of the positive-locking element 13 and the teeth 75a of the external toothing on the gear 7, or 8, are pointed on the facing end faces. As a result, engagement of the positive locking element 13 via selector lever 23 is possible upon synchronization of the components to be engaged, without needing a trough-shaped groove 18 of the slide track 70 (refer to Fig. 4 and 5). In this case, the connecting aperture 17 is fashioned as a groove extending rectilinearly across the entire width of inner ring 60 of positive-locking element 13.

If instead of springs 20 and 21 in the illustrated embodiment (Fig. 1 through 5) only one strong spring were provided, said heavy spring would force the compression body 19 immediately back again to the neutral center position 63 (Fig. 5), sliding on the shell line of the conic catch 16, as soon as the friction moment on friction faces 72 and 73 is eliminated, that is, with identical speed of rotation of power input and power output. The slight manual force acting on the selector fork 23 would then not suffice for lifting the compression body 19, spring-loaded by the heavy spring, from the conic catch 16 via the connecting aperture 17 into the trough-shaped groove 18. Nonetheless, one spring will suffice when providing the conic catch 16 with a step at the level of the bottom 81 (Fig. 4) of the connecting aperture 17. This step retains the compression body 19 in its return at the level of bottom 81, so that slipping it through the connecting aperture 17 will again require only a slight manual force.

Fig. 7 through 9 show a further embodiment of a locking-synchronizing system with basically same transmission of force. An annular body 30

is mounted again on shaft 9. Said body features, instead f toothings, on its periphery several axially parallel grooves 31 for the locking b dies and several continuous, axially parallel grooves 32 (Fig. 8) for the positive-locking parts. Grooves 31 and 32 may alternate in axially parallel fashion on the circumference of the annular body 30. But it is also possible to coordinate, e.g., with each groove 31, two grooves 32. The grooves 31 extend from the two end faces of the annular body toward its center in a fashion such that a cam 33 with bevels 50 is formed in the center.

The positive-locking element 34 rests on the annular body 30, with its inner ring, which by means of stays 35 is joined to the outer ring 58, which is engaged by the selector fork 23. The positive-locking element 34 has on the circumference of the inner ring 38 holes 36 serving to accommodate locking elements ~~32~~ 42, for instance balls, which are provided at same distribution and in same number as the grooves 31. The positive-locking element 34 with pins 37 arranged on its inner circumference is via selector fork 23 axially movable in the grooves 32. At least one of the pins 37 is on its ends provided with a round or pointed top, for threading into the holes 39 of gears 7, or 8, whereas the other pins have flat end faces. The gears 7 and 8 possess on the same diameter as that of the pins 37, situated side by side on the entire circumference, equally sized holes 39 that overlap with their countersinking 82 (refer to Fig. 10). The positive-locking pins 37 may act on inner ring 38 of positive-locking element 34 in such a way that said ring is rotatable relative to the positive-locking pins 37, but is axially movable jointly with them. This design presupposes that a ball pin 51 yet to be described in detail and acting as

a catch first retracts completely not until the balls 42 rest already n bevels 50, and thus in the gr oves 31.

Bearing on the positive-locking element 34 are several compression bodies fashioned as blocks and allowing axial motion within a frictionally engaging element 48. On the side toward the shaft 9, the compression bodies 40 possess recesses 41 which in peripheral direction are fashioned circularly and feature beveled side surfaces. Centrally in axial direction, the recess 41 is intersected by a groove 49 extending axially. Said groove has a depth such that the balls 42, retained in the holes 36, can slide in it and in the grooves 31 in centrally nested state.

The compression bodies 40 are by means of axial guides 43 axially movable in the single-part frictionally engaging element 48, which again is designed as a twin male taper, but their arrangement is rotationally fixed. The frictionally engaging element 48 has on its periphery radial openings 44 traversed by stays 35 of the positive-locking element 34. Concentric to the shaft 9, springs 45 are arranged axially on both sides of the compression bodies 40. Installed under prestress, springs 45 are axially fixed, on the end facing toward gear 7 or 8, by a clamping ring 46 each, while on the end facing the balls 42 they are fixed by the stop of a washer 47 on projections 84 of the hole 83 of the frictionally engaging element 48. The gear 7, or 8, to be engaged, is provided with a friction surface 73 whose inclination is the same as that of the friction surface 72 of the frictionally engaging element 48.

The mode of operation of the locking-synchronizing system, basically, is the same as that described in the first embodim nt. As the select r lever 23 shifts, for instance t th l ft, al ng with the positive-locking

element 34, the ball 42 acting as a locking element and the compression body 40 force the frictionally engaging element 48 elastically onto the gear 7 to be engaged. Ball 42 then slides across the surface of cam 33 up onto bevel 50.

The frictional moment occurring on friction surfaces 72 and 73 rotates the frictionally engaging element 48 relative to the positive-locking element 34, and thus the compression bodies 40 relative to the balls 42. The latter bear on the noses 85 of compression bodies 40. Hence, their passage through groove 49 is blocked (refer to Fig. 9). In the process, the balls 42 are forced on bevels 50. Generated thereby is an axial thrust which via the balls 42, compression bodies 40 and the spring 45 augments the contact pressure of friction surfaces 72 and 73.

Once ball 42 has proceeded along bevels 50 down to the bottom 86 of groove 31, it acts now — the same as in the first embodiment — Fig. 1 through 6 — as a limit to the contact force for the friction surfaces 72 and 73. Hence, the maximum contact force on the friction surfaces 72 and 73 matches the force stored in spring 45.

The spring 45 relaxes during synchronism. With appropriate retraction of the frictionally engaging element 48 relative to the positive-locking element 34, the balls 42 proceed again to their home position (Fig. ~~4~~8) and can now be pushed from that position, by a slight manual force exerted on selector fork 23, into grooves 49. The lockout is eliminated; the positive-locking element 34 allows sliding shifting, along with its positive-locking pins 37, for positive engagement of gear 7, or 8.

The locking-synchronizing system according to the invention being intended for use notably in heavy truck gearb xes, helical springs 45 are

favorably substituted by Bellville spring washers for determining the contact force; these are preceded by a light accessory spring that can be overcome by a slight manual force in order to move the balls 42 upon establishment of synchronism into grooves 49. Relative to the shaft 9, the locking-synchronizing system is axially fixed by way of a spring-loaded ball pin 51.

A further embodiment of the locking-synchronizing system according to the invention is shown in Fig. 10. The functional sequence for generating the axial thrust and the type of lockout correspond basically to those described in Fig. 7 through 9. The locking elements ? 52 ~~51~~ are radially retained in the positive-locking pins 90 and bear outwardly inside the conic catches of the compression bodies 89, and inside on the cams 33 or on the walls of axial grooves 31 with appropriate bevels 91 and the bottoms 87 of shaft 55. The structure of the springs 20 and 21 that determine the contact force corresponds to that illustrated in the embodiment relative to Fig. 1 through 6. The present embodiment is narrower still, since the inside arrangement of shift rods 53 allows designing the frictionally engaging element 80 with its friction surfaces 72 in roof fashion and achieving a large frictional diameter. Arranged in the shaft 55 are several axial grooves 54, for instance 3, for the shift rod 53, which can be moved axially, outside the casing, by the selector fork 56. This arrangement of selector fork 56 is especially favorable in 2-speed gears, since the narrow design can be fully utilized here. The locking-synchronizing system is axially fixed relative to the shaft 55? ~~53~~ via spring-loaded ball pin 51. As the frictionally engaging element 80 contacts the gear t be engaged, for instance gear 7, the r tation of the fricti nally engaging

element 80 with the compr ssi n body 89 relative to the positive-l cking pin 90 with the locking element 52, the nose 88 f compression b dy 89 proceeds to a lock-out position for the locking element 52, similar to Fig. 9. Only upon establishment of synchronism is the locking element 52 allowed to slide through the axial groove ~~82~~ 92, for positive locking.